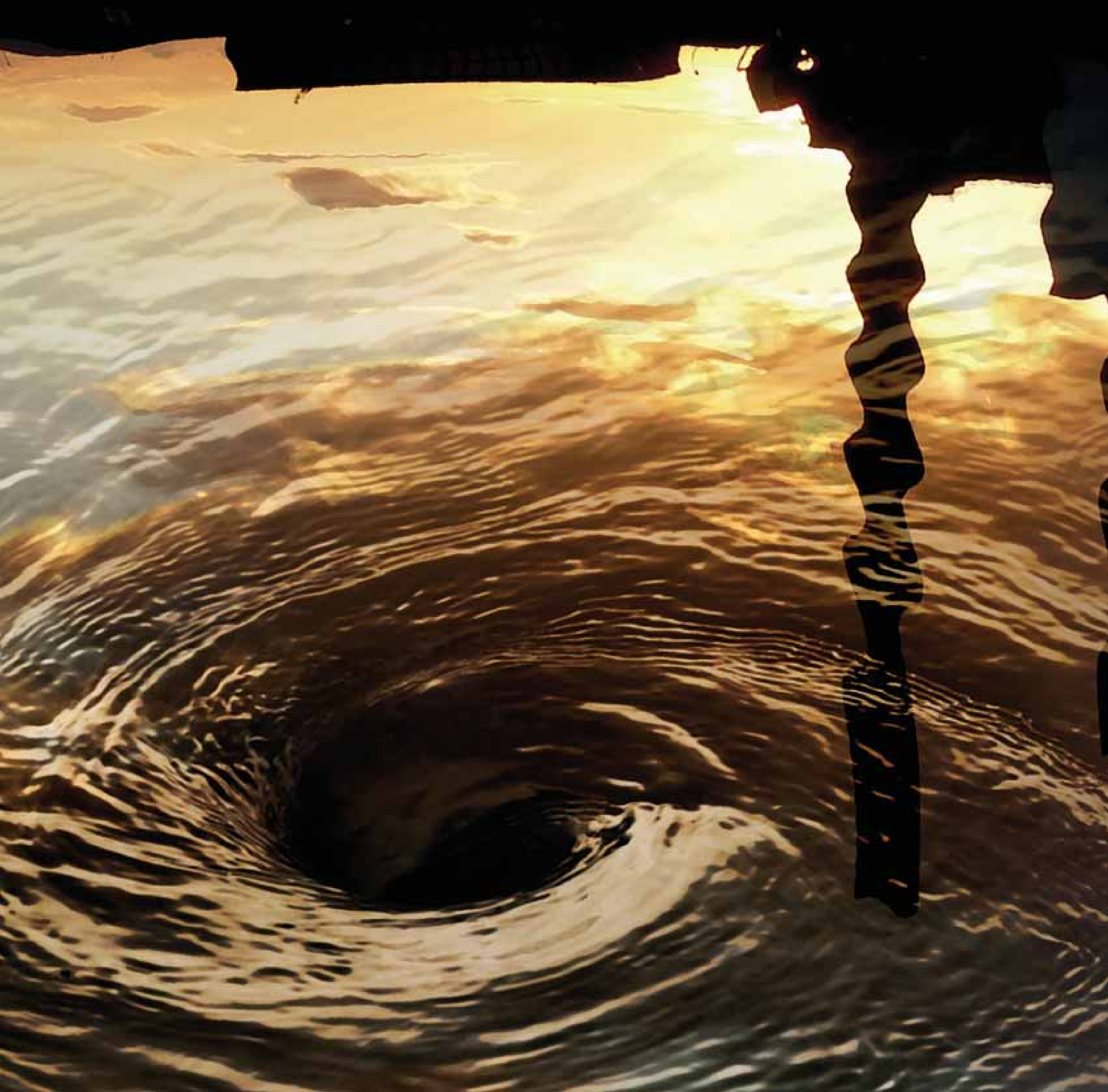
RUNNING DRY



AT THE POWER PLANT

The Story in Brief

Securing sufficient supplies of fresh water for societal, industrial, and agricultural uses while protecting the natural environment is becoming increasingly difficult in many parts of the United States. Climate variability and change may exacerbate the situation through hotter weather and disrupted precipitation patterns that promote regional droughts. Achieving long-term water sustainability will require balancing competing needs effectively, managing water resources more holistically, and developing innovative approaches to water use and conservation. Utility companies—which use substantial amounts of water for plant cooling and other needs—are doing their part by pursuing water-conserving technologies, innovative recycling schemes, and alternative sources of water to deal with the squeeze on freshwater availability.

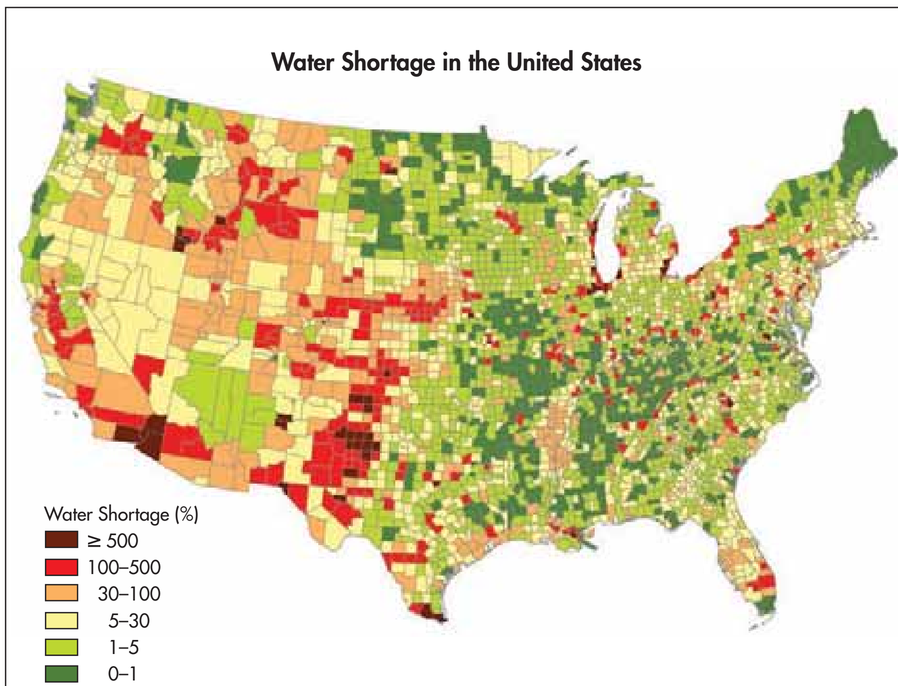
Seventy-five percent of the water used in the western United States begins as snowpack stored in the high mountains. As the days lengthen into spring and summer, the runoff feeds the region's great watersheds and rivers, where it is captured and stored a second and third time in an extensive infrastructure of dams and reservoirs. From there the water is parceled out in increasingly complex formulas to farmers and ranchers, to cities and municipalities, and to wildlife and the environment. While the supply of fresh water in the West appears to be declining, population continues to grow, bringing with it not only increasing competition for water but the search for a long-term sustainable solution.

Over the next 25 years, the United States will add 70 million people, with most of the population growth concentrated in the water-short areas of the Southwest, the Far West, and even the Southeast. Los Angeles may have been the harbinger of desert urbanization. The city was built on the presumption of fresh water: the city reasoned that if it imported water in abundance, people would follow and the desert would bloom. The strategy worked. Today, greater Los Angeles stretches out to cover nearly 5000 square miles of irrigated land. Similar scenarios are now playing out in some of the country's fastest-growing cities—Las Vegas, Phoenix, and Salt Lake—despite the prospect of long-term drought looming over the West. Snowpack levels are down throughout the mountain region, and with warmer temperatures, the spring runoff now begins 10 days earlier on average. Meanwhile, to sustain its growth trajectory, Las Vegas is trying to bring groundwater 280 miles from the northern valleys of Nevada despite opposition from local farmers and ranchers, and the booming exurbs of Salt Lake have proposed a 120-mile pipeline to tap into Lake Powell, which is now at its lowest level since 1973.

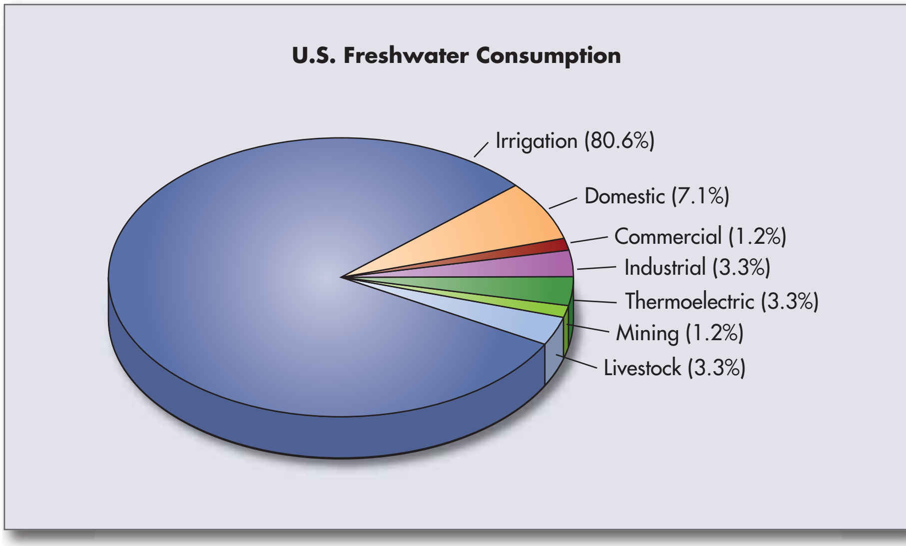
Water Sustainability

Water sustainability is not just a western concern. It is an issue throughout the United States and in most areas of the world where population pressures are mounting. According to the Government Accountability Office, 46 states expect water shortages over the next 10 years; some of the shortages will be statewide, others will be more localized. Few new reservoirs have been built in recent years, in part because of environmental opposition and in part because there is little unsubscribed water left. Surface water supplies in the United States have not increased in 20 years, forcing suppliers to pump more groundwater to meet demand. This is bringing the water issue to a head, as groundwater supplies all over the country are declining sharply. According to a report to Congress from the Department of Energy's Energy-Water Nexus Committee, "Some regions have seen groundwater levels drop as much as 300 to 900 feet over the past 50 years because of the pumping of water from aquifers faster than the natural rate of recharge." In the Chicago/Milwaukee area, demand has exceeded precipitation, and groundwater levels are declining as much as 17 feet per year in some locations. In the High Plains, groundwater levels have been reduced by 100 feet; in Houston, by up to 400 feet; and in Tucson/Phoenix, by 300–500 feet. On Long Island, stream flows are declining and salt water is moving inland. Even in the water-rich Pacific Northwest, the groundwater level has declined by 100 feet.

Viewed as a problem of sustainability, the long-term challenge for water supply is to maintain steady growth in living standards without compromising the ability of future generations to meet their own needs and aspirations. Natural waters serve many functions: They provide water supply for domestic and industrial uses; for energy, mining, and transportation; for agriculture; and for recreation. They also supply habitats for wildlife and aquatic life. Sustainability requires keeping these competing needs in balance, managing our water



The degree of water shortage in an area can be defined as the total freshwater withdrawal divided by the available precipitation (precipitation minus evapotranspiration), expressed as a percentage. Freshwater withdrawals already exceed precipitation in many parts of the country, with the most dramatic shortfalls in the Southwest, in the High Plains, in California, and in Florida. (source: Solley at al./EPRI)



While thermoelectric power generation accounts for roughly 40% of U.S. freshwater withdrawals, much of this volume is used in once-though cooling systems, which return most of the water to the source after use. Thus, power plants actually account for only about 3% of total consumption. (source: Solley et al.)

resources more efficiently and more holistically, finding innovative ways to conserve and recycle water to meet growing demand, keeping water in streams and water bodies to protect the natural environment, and preparing for possible changes in temperature and precipitation from climate change.

Sustainability will require a major reconsideration of our water infrastructure and management practices, according to Bob Goldstein, EPRI's technical executive for water and ecosystems: "Our water infrastructure was designed for a future that is now in our past. We have three major forces driving future water usage and quality—population pressures, environmental protection, and uncertainty about future climate—and our existing infrastructure and inherited management practices are not based on any of these three. As Yogi Berra once said, 'The future ain't what it used to be.' Consider the Colorado River Compact. It was designed at a time—the early twentieth century—that we now recognize from a historical perspective to have been an extremely wet era in terms of runoff. You total the existing allocations and the sum is greater than the river flow."

According to the report of the fourth Intergovernmental Panel on Climate Change, precipitation patterns are likely to move northward, and areas prone to drought, such as the Colorado watershed, are likely to become more arid as the twenty-first century progresses. Some hydrologists foresee the snowpack in the Sierra Nevada declining by 25% by 2050, forcing large-scale constraints on water consumption in California. Nobody knows for certain which areas of the country are likely to become substantially wetter or drier, because the predictive capabilities of climate modeling are still too imprecise. Nevertheless, long-term planning is beginning, and it is apparent that moving fresh water over longer distances will be easier than relocating populations, businesses, and industries. This transport will almost certainly require larger regional compacts among multiple jurisdictions to manage watersheds on a shared basis and to help resolve the political complexities of one region's subsidizing another's water demand.

As one of the major users of water, electricity generation will be required to do its part and, given its technical potential, to take a leadership position in water conservation. Far and away the largest use of water by power plants is for cooling—that is, for condensing the steam flowing out of the turbine-generator and using the water to carry the rejected heat into the atmosphere via cooling towers or by using a water body for once-through cooling. Other major uses of water in the power plant include flue-gas scrubbing, ash sluicing, boiler makeup, gas turbine inlet cooling, dust control, and "housekeeping" activities.

Power and Water Issues

Until the early 1970s, most power plants were located next to a sizable body of water or a major river to ensure adequate water for cooling. These plants used once-through cooling, a process that simply borrows the water, uses it to condense the steam from the turbine, and then returns it to the original water body some 20°F warmer. While highly efficient for cooling, the process has the potential for a twofold impact on aquatic life: fish entrainment and impingement at the front end of the process, and thermal discharge at the back end. Newer units have typically employed evaporative cooling towers in a process known as wet cooling, which withdraws less than 5% of the water needed for once-through cooling. As a result, fish entrainment is minimized and thermal discharge significantly reduced. There are, however, potentially significant local and environmental tradeoffs with cooling towers, including discharge of waterborne pollutants used to control scaling and fouling, release of particulates in air emissions, salt drift, noise, and aesthetic issues.

Over 30% (by capacity) of today's fleet of thermoelectric power plants still utilize the once-through cooling process. The result is that power generation accounts for roughly 40% of freshwater withdrawals in the United States—a figure comparable to the withdrawal level of U.S. agriculture—whereas it accounts for only about 3% of the country's water *consumption.* It is critical to recognize, however, that although the once-through plant consumes only a small fraction of the water it withdraws, it needs the withdrawal to operate. Hence, under drought conditions, a generating plant may have to be shut down or severely curtailed in operation because of its inability to withdraw a sufficient amount of water to meet its thermal discharge permit.

According to John Maulbetsch, a cooling systems expert and EPRI consultant, "We increasingly read and hear that water is too precious to waste on cooling power plants. This can be debated. However, we need to realize that power plants can have a major impact on local water availability. A 1000-MW power plant with wet cooling consumes approximately 10,000 gallons of water a minute through evaporation. When this requirement is imposed on a region that already anticipates shortages for agricultural and municipal needs, it is clearly disruptive and the subject of controversy."

In recent times, water has become a more contentious siting issue for power production—notably in the Southwest, but elsewhere as well. In Idaho, for example, two proposed power plants were opposed by local interests because of the impact on a key aquifer. The governor of Tennessee imposed a moratorium on the installation of new merchant power plants because of cooling constraints. In response to these situations, and in some cases to expedite the siting process, some power producers have moved beyond evaporative cooling towers to the newer and more expensive dry-cooling technologies. One of the premier installations of dry cooling is at the 1600-MW Mystic generating station situated on Boston Harbor; the driving concern in this case was the protection of aquatic life, not water availability.

In the future, says Maulbetsch, "The competition for water will require electricity generators to address conservation of fresh water. There are a number of avenues to consider. One is to use dry-cooling and dry-scrubbing technologies. Another is to find innovative ways to recycle water within the power plant itself. A third is to find and use alternative sources of water, including wastewater supplies from municipalities, agricultural runoff, brackish groundwater, or seawater." He points out that all of these approaches alter the economics of power generation. Dry technologies are usually more capital intensive and typically exact a penalty in terms of plant performance, which in turn raises the cost of power generation. On the other hand, if the cost of water increases in response to greater demand, the cost differences between dry and wet technologies will be reduced.

Dry and Hybrid Technologies

More than 60 power generation facilities

The Break-Even Cost of Water

Engineers evaluating the design of a power plant cooling system will typically try to estimate the so-called break-even cost of water—the point where the total lifetime cost of dry cooling equals the total cost of wet cooling. The capital cost of a dry system will typically run four times the cost of a comparable wet system but can be offset by decades of reduced water consumption and the reduced associated costs.

Water costs include the cost of acquisition or purchase, the cost of delivery, and the cost of treatment and discharge or disposal. Each of these costs can vary by an order of magnitude, depending on plant location, water source, and the requirements of the local jurisdiction.

The cost of acquiring water depends on the geographic region and on whether water use is oversubscribed or undersubscribed in the local area. It also depends on whether the water is purchased outright on an annual basis, or whether the user is able to buy the water rights, which entitle the owner to an agreed number of acre-feet of water per year in perpetuity. Water rights law is complex and varies dramatically from state to state, and the cost range is large. In New Mexico, freshwater costs have increased to $70 per acre-foot for plant cooling water. In California, where the cost of water is quite high, plants can pay up to $400 per acre-foot for reclaimed water (90% of freshwater costs).

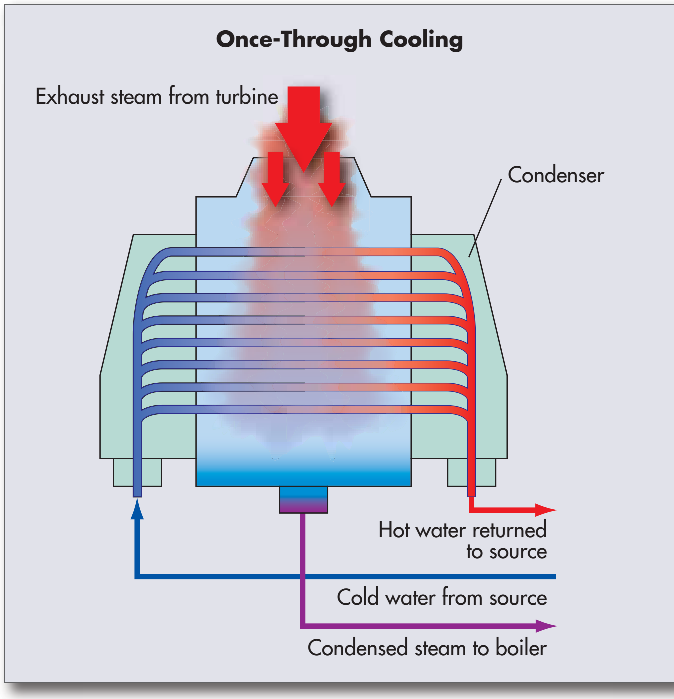
The costs of transporting water from the source to the power plant site include the capital cost of the pipeline and the operating costs for pumping the water. Installation costs are affected by the length of the pipeline and the route. Routes through urban areas can double or triple pipeline costs.

Treatment includes the initial cleanup for in-plant use and preparing the used water for discharge or disposal. Costs are primarily for chemicals, power, maintenance, and labor. The level of treatment required for the disposal of water and/or treatment solids can vary widely; if the plant must operate in a zero-liquid-discharge mode, costs will be at the high end of the range.

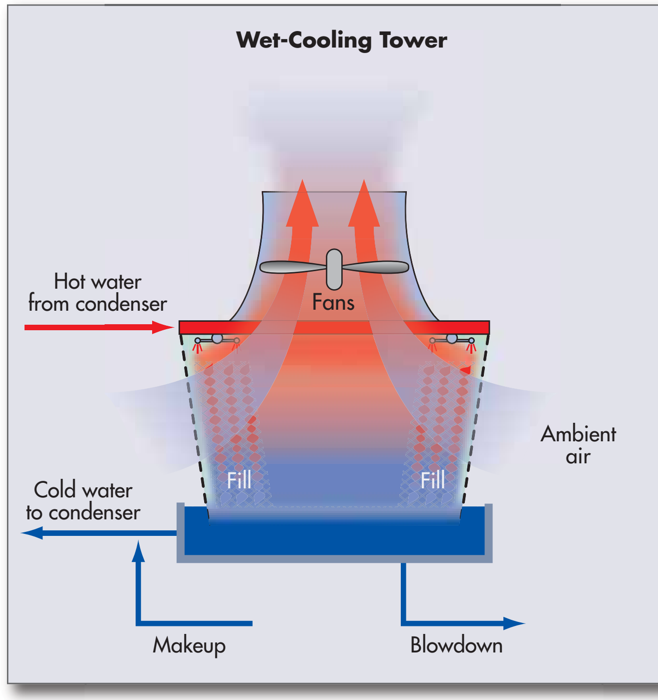
The complete cost picture for water acquisition, delivery, and treatment is shown in the table. The range represents an order-of-magnitude difference between low total cost and high cost. At the extreme, the high cost represents an unlikely combination of negative factors—poor-quality water requiring lengthy uphill pipeline transport to a zero-discharge site. Future costs could be significantly higher.

U.S. Water Costs ($/1000 gal)

	Minimum	Low	Medium	High
Acquisition	<$0.01	$0.05	$0.15	$0.50
Delivery	<$0.01	$0.13	$0.57	$1.20
Treatment/Disposal	$0.10	$0.25	$1.00	$4.00
TOTAL	~$0.10	$0.43	$1.72	$5.70



A once-through cooling system takes water directly from a source—a river, lake, or ocean—uses it to condense exhaust steam from the turbine, and then returns the water to the original source about 20°F warmer. Roughly 30% of U.S. thermoelectric capacity still uses once-through cooling.

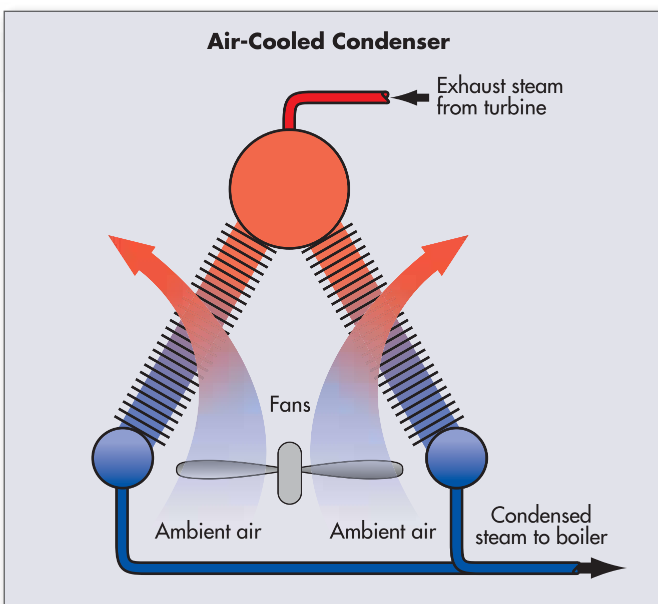


In a wet-cooling system, hot water from the plant's condenser is piped to the top of a cooling tower, where it flows downward through fill material cooled by ambient air. Addition of makeup water is necessary to replace water lost by evaporation and blowdown.

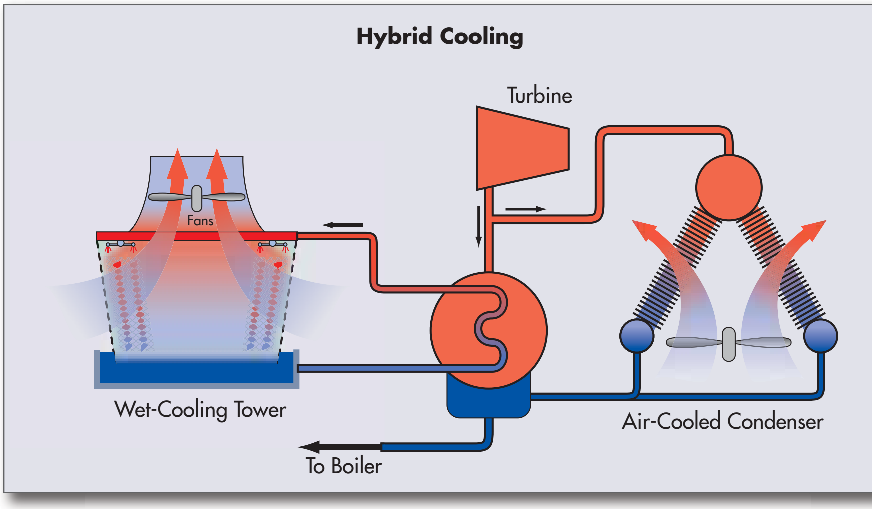
in the United States now use dry cooling in lieu of conventional wet cooling. Most are relatively small units, but there are sizable units (>300 MW) using air-cooled condensers in California, Massachusetts, Nevada, Wyoming, and New York.

The principal components of a conventional wet-cooling system are the condenser, the wet tower, and the circulating water system. The turbine exhaust steam flows over the outside of the condenser tubes, where it gives up its heat to the water inside the tubes. The warm water in the tubes is then piped to the cooling tower. From there it flows downward through the packing, or "fill," which is designed to break the water up into small droplets or spread it out into a thin film to maximize the surface area exposed to the cooling air, which is drawn through the tower by a large fan or by natural convection. Evaporation typically carries off 85–90% of the heat, and convection dissipates the remaining 10–15%. Roughly 2% of the cooling water is lost through evaporation, requiring continuous addition of makeup water. Since evaporation results in the buildup of dissolved solids in the circulating water, a portion of the water is discharged as "blowdown" to limit the concentration of these solids and prevent the formation of mineral deposits, which can interfere with the transfer of heat from the condenser to the cooling water.

Where water is at a premium or its use restricted, the major



Dry-cooled plants feed turbine exhaust steam into the large ducts of an air-cooled condenser. As the steam passes down through the condenser's finned tubes, ambient air blown through the structure condenses it and carries off its heat, working much the same way as a automobile radiator. Dry-cooling systems typically exact a penalty on power plant efficiency.



Hybrid cooling systems, which combine an air-cooled condenser with a wet-cooling tower, can offset the efficiency disadvantage of all-dry systems. The wet system is used only on the hottest days of the year, when dry systems are least efficient. Hybrids can economically reduce the water that would be required by all-wet systems by as much as 80%.

alternative to wet cooling is dry cooling, which uses an air-cooled condenser (ACC). In a dry system, the steam from the turbine is carried in large ducts to the ACC, where the heat is transferred directly to the air passing over the surface. In much the same way cars, refrigerators, and electronics expel their heat, the ACC uses a large number of external fins to increase the surface area exposed to the cooling air.

The ACC is normally designed in the shape of an A-frame, with steam entering along the apex and condensing as it passes downward through finned tubes. There is a key engineering advantage in keeping the steam duct as short as possible to minimize steam pressure losses. As a result, the ACC is normally located near the turbine building itself.

Dry cooling offers distinct advantages in terms of dramatically reducing water consumption while increasing flexibility in power plant siting. The capital cost of dry cooling is considerably higher than that of wet cooling, however, and the dry process typically exacts a penalty on power plant performance on the order of 2% (annual average for an optimized system). For a few hours on the very hottest days of the year, efficiency penalties from dry cooling can rise to more than 20%, requiring more fuel and increasing greenhouse gas emissions.

The capital and operating cost disadvantage of dry cooling can be partially offset, however, by the elimination of most water-related costs. These include the costs of acquisition, delivery, treatment, and discharge and the cost of fish and marine life protection. Sometimes it is not the cost or availability of water that is driving the decision to choose dry cooling, but rather licensing delays because of concerns of the community or agency over competing uses of water.

The capital costs of cooling systems are specific to the size and type of plant, but the installation of dry cooling can cost more than four times that of wet cooling in hot, arid regions, dropping to a factor of three in regions with cooler climates. This is because dry systems are more inefficient in hotter climates. For example, the capital cost of a dry-cooling system for a 500-MW combined-cycle plant could run $21 million to $26 million, compared with $6 million to $7 million for a wet-cooling system, depending on the location.

Wet- and dry-cooling systems can be combined into hybrid systems to gain the advantages of both and offset the disadvantages of each. A hybrid system can be used, for example, to substantially reduce the makeup water consumed in wet cooling without incurring the large increases in heat rate (and thus decreases in generating capacity) associated with all-dry systems. The capital costs tend to fall midway between the all-dry and all-wet systems.

Hybrid systems designed for maximum water conservation are essentially dry systems with just enough wet-cooling capability to prevent significant deterioration in power plant efficiency during the hottest days of the year. Sometimes these systems are referred to as dry/wet-peaking cooling tower systems. When temperatures rise, the wet-cooling system is turned on, improving heat rates and generation capacity. These systems can economically reduce the amount of water that would be required by all-wet systems by as much as 80%.

In-Plant Conservation

The ongoing drive to conserve water has been extended to a wide variety of innovative processes to recover, recycle, and reuse the water already in use in the power plant. This approach calls for treating the water to isolate and remove the contaminants that invariably build up as the plant systems and subsystems perform their functions, and sending the recovered water back into use. The goal is to reduce the amount of fresh water required for makeup at the front end and to reach a point of minimized water use or even zero discharge at the back end.

Different uses in the plant have different requirements for the purity of the water. Maulbetsch says, “In general, if water is to be treated for reuse, it is preferable to treat it completely for the highest level of use and then let the water cascade down to lower-quality uses, rather than clean it up just a little bit for an intended intermediate use.”

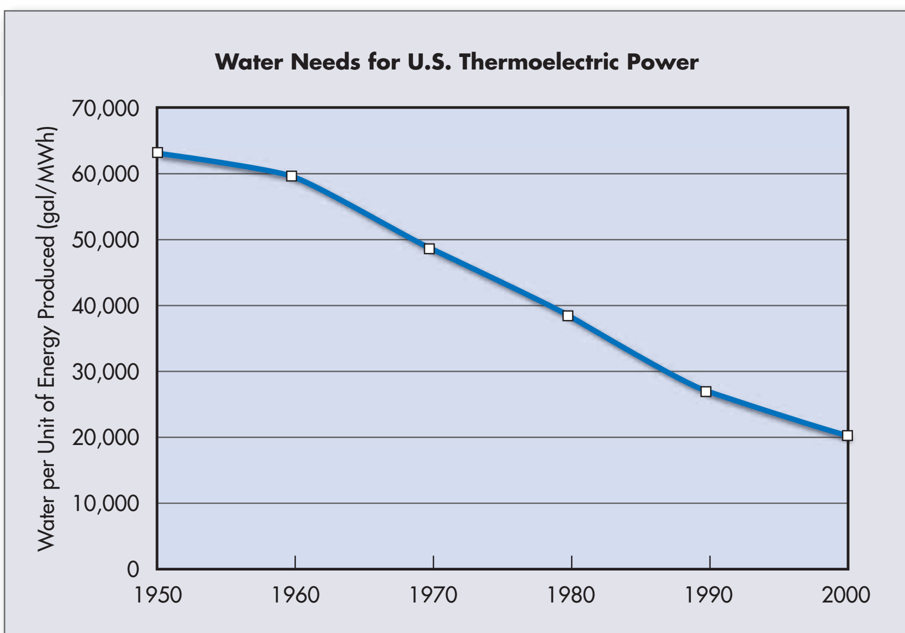
He points to one of the most highly integrated water-recycling operations, now in use at Public Service of New Mexico’s San Juan generating station in the Four Corners area. Six streams of wastewater exit the plant and go through multipronged treatment before reentering operations.

Boiler feedwater requires the highest quality, and the wastewater used for this process goes through both distillation and demineralization processes before heading off to the boiler. The intermediate-quality distilled water is sent to the cooling tower. And the lowest-quality water is sent directly from the wastewater pond to the limestone preparation operation. With this integrated process, 97.5% of the water consumed is evaporated in the tower or goes up the stack; less than 1% ends up in the evaporation pond for disposal.

Comparable technologies are being developed for conserving the water used for flue gas scrubbing and ash handling, and more-experimental techniques are expected to recapture some of the water exiting in the cooling tower plume or escaping up the stack. In the traditional operation of a flue gas scrubber, the sulfur dioxide is removed from the flue gas by spraying a limestone slurry into the gas stream. The SO_2 reacts with the calcium in the slurry to form calcium sulfate or sulfite, which falls to the bottom as a wet solid. Some of the water is separated out in a recycle tank and sent back to the scrubber; some is lost through evaporation up the stack; and the remainder stays with the wet solids, which are either landfilled or used commercially for materials such as gypsum wallboard.

Dry cooling has obvious advantages in water-constrained regions but may be a good choice elsewhere as well. For example, the Mystic generating station on Boston Harbor chose a dry system over once-through cooling to avoid concerns over possible impacts on aquatic life.

One option for reducing the amount of water lost through traditional scrubbing involves cooling the flue gas before scrubbing. Reducing the stack gas temperature by 25°F can reduce evaporative losses by 15–20%. Another option for some plants is an alternative SO_2 dry-scrubbing process in which an alkaline reagent is atomized and sprayed into the hot flue gas to absorb the SO_2. About 20% less water is used in this process than in wet scrubbing, and the residue comes out as a dry product that is airborne, rather than as a wet solid. The dry material in the flue gas is captured by a particulate control device, typically a baghouse.



The efficiency of U.S. water use has improved substantially over the last half century. While the volume of water withdrawn for power plant needs has increased by a factor of 5 since 1950, the amount of power generated has grown even faster—by a factor of 15. As a result, the water withdrawn per megawatthour has decreased by more than two-thirds. (source: Limno-Tech, Inc.)

Alternative Sources of Water

Alternative water supplies offer significant opportunities for power plants to limit their use of fresh water. Potential sources include municipal effluent, wastewater from industrial operations, water brought up by oil and gas production, and agricultural runoff, as well as brackish groundwater and seawater. According to the Department of Energy, "With wastewater reclamation and desalinization growing at rates of 15% and 10%, respectively, nontraditional water consumption could well equal freshwater consumption in the U.S. within 30 years."

Municipal wastewater undergoes extensive treatment in the 25,000 municipal effluent facilities in the United States. Typically, the treated water is then discharged into waterways or allowed to percolate in disposal ponds. Only about 8% of the 32 billion gallons per day (BGD) of treated "gray water" is reclaimed or recycled. Gray water represents one of the largest untapped resources of relatively clean water for the future, and its use is projected by DOE to grow from 2.6 BGD in 2006 to 12 BGD by 2015.

Mike DiFilippo, a recognized power industry water chemist, says that municipal wastewater was first used for power plant cooling over 40 years ago. "Initially, only a few plants in California, Texas, and Florida used municipal effluent for cooling," he says. "But in the past 10 years, the use of this resource has increased dramatically, and hundreds of plants are using municipal effluent today. There are several zero-discharge or near-zero-discharge plants using municipal effluent in the Southwest." Zero liquid discharge (ZLD) plants have no water discharge to a receiving water body.

DiFilippo points out that the technical and economic issues in using municipal wastewater vary by plant and location: "Depending on the plant and the final disposition of the plant's wastewater stream, the use of municipal effluent can be relatively simple. At plants where municipal effluent is used in lieu of fresh water and where cooling tower blowdown can be discharged directly, municipal effluent is often incorporated easily into plant operations. In these scenarios, the plant metallurgy must be compatible with the treated effluent. At ZLD plants, municipal effluent is generally more costly to use, but this depends on the freshwater source."

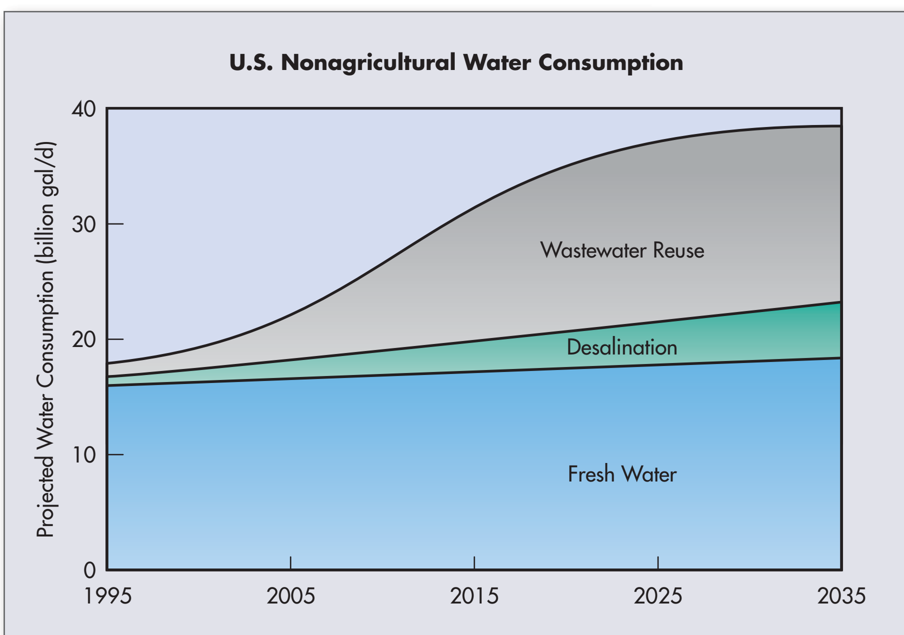
Some of the pioneers in using municipal wastewater include Burbank Power and the Delta Energy Center in California, Southwestern Public Service in Texas, Lakeland Electric in Florida, Public Service Electric and Gas in New Jersey, AES Granite Ridge in New Hampshire, and the Palo Verde nuclear generating station in Arizona.

At Palo Verde, gray water has been used for cooling the three-unit, 3875-MW plant for over 20 years. The gray water is pumped 35 miles from Phoenix, put through an additional (tertiary) stage of treatment, and then stored in a large (760-million-gallon) lined reservoir. The treatment process is elaborate. Effluent is put through trickling filters to reduce ammonia content and adjust alkalinity. Clarifiers are used to remove phosphates and magnesium. Chemicals are used to reduce the level of calcium carbonate, which otherwise would tend to cause a buildup of scale. Finally, gravity filters are used to remove any remaining suspended solids.

There are large brackish groundwater aquifers throughout much of the interior United States. Texas alone, for example, has an estimated 2.5 billion acre-feet of such water, the equivalent of a thousand-year withdrawal at a level equal to 10% of current U.S. freshwater consumption. Treatment costs can range from $1.50 to $3.00 per 1000 gallons, depending largely on salinity, which varies greatly by region from 1000 parts per million (ppm) to 20,000 ppm. Brackish groundwater can also contain high levels of scale-causing compounds, such as carbonate, sulfate, and silica.

Seawater has been used for power plant cooling for decades along the coasts. Its use today is estimated at around 60 BGD. Salinity levels are quite high but are offset by low levels of carbonate, sulfate, and silica, which cause scaling. The real impediment to future use of seawater is the ecological impacts, including the entrainment and impingement of various organisms at the intake structure, the effects of the thermal effluent streams, and the public's growing desire for industry-free coastlines.

Another option is use of produced water, a byproduct of oil, gas, and mining operations. "On average, a barrel of oil brings up about six barrels of produced water, representing a significant source for the future," says DiFilippo. "The quality varies greatly by region and by local geology, with salinity levels ranging from 500 ppm to over 400,000 ppm. Produced water can also have high levels of organics and soluble hydrocarbons, and water from mining operations may contain heavy metals and naturally occurring radioactive materials."



Alternative water supplies offer significant opportunities for power plants to limit their use of fresh water. Nonagricultural water consumption is expected to double in the next 30 years, and most of the increase will come from treated wastewater. (source: DOE)

R&D Priorities

The U.S. power industry and our entire society are facing more and more pressure to use less and less water. According to Bob Goldstein, "As a society, we should manage this issue proactively, intensively, and in an integrated manner. A key is to approach the issues not only on a facility-by-facility basis—a power plant, a municipal treatment center, a bottling plant—but also holistically, recognizing that water is a shared community resource. Every sector of the economy and society has a stake in sustainable water use."

Goldstein points out that whether the industry pursues water management proactively or reactively, it still needs the tools that science and technology can provide. EPRI is developing a comprehensive $35 million R&D strategy based on business and economic considerations for the power industry. The strategy includes five primary elements:

- Developing and applying an engineering and economic framework for evaluating new water-conserving power plant technologies
- Improving dry and hybrid cooling technologies
- Reducing water losses in cooling towers
- Effectively using degraded water sources for plant operations
- Developing water resource assessment and management decision support tools

One key element of the strategy is to reduce the hot-weather loss of cooling efficiency for air-cooled condensers. A second is to recapture water now lost as vapor from cooling towers. A third is to build a decision support framework for water management that takes into account the physical flow of water throughout an entire watershed; this would be an extension of EPRI's pioneering work in watershed assessment and management with respect to acid rain, eutrophication, and bioaccumulation of mercury in fish.

Goldstein envisions that EPRI will implement the power industry's R&D strategy through partnering with government entities and other stakeholder groups.

The Palo Verde nuclear generating station near Phoenix has been using treated municipal effluent—so-called gray water—to meet its plant cooling needs for over 20 years. The effluent is stored on-site in a 760-million-gallon lined reservoir.

Over the last several years, EPRI has published a dozen reports resulting from its studies of electric power and water sustainability. A significant portion of this work was cofunded by DOE, the California Energy Commission, and EPRI's Technology Innovation Program. EPRI has also worked closely with the national energy laboratories on the Energy-Water Nexus Report to Congress, the Energy-Water Nexus Research Roadmap, and the ZeroNet Research Initiative and has collaborated with Electricité de France on creating and testing risk management tools to address the impacts of climate change on water availability for electric power generation.

This year, a new study—with the support of EPRI's Technology Innovation Program; EPRI's Environment, Generation, and Nuclear sectors; and Electricité de France—will examine the application of air-cooled condensers to nuclear plants, the coupling of an ammonia cycle to a steam cycle to increase water-use efficiency, and the means of reducing wind interference with the operation of dry-cooling towers.

The U.S. electric power industry, in partnership with EPRI, is at the forefront of addressing the issue of managing water at its facilities. It has pioneered the use of alternative sources of water, designed and operated plants that minimize water use, and where practical, employed the use of dry and hybrid systems for cooling. In the face of growing national demands for fresh water, the power industry will continue to pursue its commitment to reducing water consumption.

This article was written by Brent Barker. Background information was provided by Robert Goldstein (rogoldst@epri.com) and John Maulbetsch (maulbets@sbcglobal.net).

Further Reading

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